The invention relates to a method of carrying out an uplink synchronisation of the signal transmission from at least one subscriber station to a base station in a radio communication system. The invention is particularly suitable for use in a mobile radio system.

In radio communication systems such as the second generation European mobile radio system GSM (global system for mobile communications), information (such as speech, pictures or other data) is transmitted over a radio interface with the aid of electromagnetic waves. The radio interface refers to a connection between a base station and subscriber stations, and the subscriber stations may be mobile or fixed radio stations. The electromagnetic waves are emitted on carrier frequencies that lie within a frequency band intended for the system concerned. For future radio communication systems such as UMTS (universal mobile telecommunication system) or other third generation systems, the intended frequencies are in the frequency band around 2000 MHz. Two modes are planned for third generation mobile radio communications. One mode is designated FDD (frequency division duplex) and the other mode is known as TDD (time division duplex). Each mode is applied in a different frequency band. Both modes support a subscriber separation method known as CDMA (code division multiple access). A proposal for a third generation mobile radio system according to "TD-SCDMA Radio Transmission Technology for IMT-2000", Draft V.0.4, of the CATT, dated September 1998, is based on the described TDD mode with support for a CDMA subscriber separation method. Using the CDMA subscriber separation method it is possible for transmission blocks transmitted by a plurality of subscriber stations in one time slot, and generally consisting of a data part and a known training sequence, to be processed in parallel by a base station. For this to happen, however, it is necessary to ensure that the transmission blocks and in particular the respective training sequences occur within a specific time slot at the base station in order to

guarantee reliable detection and separation of the different signals. This problem of synchronising the uplink signal transmission also occurs in the case of known CDMA-based radio communication systems.

The respective time bases in each of the subscriber stations are synchronised in accordance with prior art such as that already known from the GSM mobile radio system, and generally therefore during a procedure for establishing a connection, during which the base station, having received a signal from a subscriber station, sets the time reference of the subscriber station concerned by signalling a correction value. Since the time reference can change continually, for example due to movement of the subscriber station, the subscriber station time reference must be corrected periodically in order to maintain synchronisation. With this in mind the proposal for third generation mobile radio systems is to transmit special synchronisation information at a specific periodicity. The synchronisation information (SS - synchronisation shift) corresponds in this case to a specific chip increment with a positive or negative sign.

To ensure accurate control of the time reference, the time reference should be changed in the subscriber station on the basis of a time scale that is less than the chip rate. Accordingly the object of the invention is to specify a method and a subscriber station which provide a simple means of implementing synchronisation by means of a sub-chip rate.

From document WO 97/31429 a method of synchronising the transmission from a subscriber station to a base station in a CDMA communication system is known. In this method a plurality of radio blocks transmitted by the subscriber station are transmitted using in each case a time offset in the spreading code amounting to 1/2 chip.

From documents US 5,943,331 and US 5,446,727 CDMA-based communication systems are known in which the phase of the orthogonal codes or the time offset of the transmission can be adjusted in fractions of a chip.

The object of the invention is to provide a simplified means of implementing control of the time offset. This object is achieved by means of the method with the features explained in Claim 1 and by means of the subscriber station with the means explained in Claim 4. Advantageous embodiments of the invention will emerge from the individual sub-claims.

According to the invention, for the purpose of synchronising uplink signal transmission in the subscriber station, the signals to be transmitted are spread over a corresponding transmission block with the aid of an individual spreading code consisting of a number of chips in accordance with a CDMA method in the digital baseband. During pulse shaping of the chips in the transmission block a corresponding impulse response is buffered and the buffered impulse response is sampled with the aid of filter coefficient sets. Relative to each other the filter coefficient sets have a timing advance corresponding to a multiple clock rate relative to the chip rate. A timing advance for the transmission block is controlled by selecting a sampling point and/or a filter coefficient set.

Advantageously, the embodiment to which the invention relates makes it possible to use the generation of transmission blocks on the basis of a clock rate corresponding to the multiple of the chip rate to obtain the smallest timing advance corresponding to at least one clock rate cycle.

Storage of impulse responses can be carried out independently of the pulse forming procedure, for instance with the aid of a downstream, clock-rate driven memory device, or can be integrated in the pulse forming procedure.

Advantageously, sampling of the buffered impulse responses with the aid of a plurality of filter coefficient sets can be controlled by means of a larger timing advance increment if the sampling is carried out at a lower clock rate than the time difference between the sampling points of the filter coefficient sets.

According to an embodiment, the clock rate is selected as a whole number multiple of the chip rate. A 2^n-fold multiple of the chip rate appears to be particularly advantageous for this purpose, since the clock rate can also be used for generating the chip rate by means of a cascade of clock-rate splitters.

According to a further embodiment, the filter coefficient sets can be advantageously stored in a memory device for example, and be selected or adaptively determined in accordance with the required timing advance.

Exemplary embodiments of the invention are explained in greater detail with reference to the attached drawings, in which;

FIG 1 shows a block diagram of a radio communication system,
FIG 2 shows a diagram of the frame structure of a radio interface with a TD/CDMA subscriber separation method,
FIG 3 shows a synchronisation-control flow diagram for the uplink signal transmission,
FIG 4 shows a block diagram of a transmission branch in a subscriber station,
FIG 5 shows a block diagram of the spreading and modulation of signals in the transmission branch shown in FIG 3, and
FIG 6 shows the generation of a plurality of filter coefficient sets.

FIG 1 shows part of a mobile radio system as an example of a radio communication system structure. A mobile radio system consists not only of a plurality of mobile switching centres MSC which are associated with a switching network SSS (switching sub-system) and

are networked together or provide access to a fixed network, but also of one or more base station sub-systems BSS connected to the said mobile switching centres MSC. A base station sub-system BSS also has at least one device RNC (radio network controller) for allocating technical radio resources, and has at least one base station NB (node B) connected to it.

A base station NB can use a radio interface to establish and maintain connections to subscriber stations UE (user equipment). Each base station BTS forms at least one radio cell Z. The size of the radio cell Z is defined as a rule by the coverage of a general signalling channel BCH (broadcast channel) transmitted by the base stations NB, using in each case a constant, maximum transmission power. In the event of sectoring or hierarchical cell structures, further radio cells Z can be managed per base station NB. The functionality of this structure can be transferred to other radio communication systems in which the invention may be used.

The base stations NB of the above-mentioned TD-SCDMA mobile radio system have antennas with modifiable directional characteristics, so that after direction finding for the reception and specific transmissions, the directional characteristic can be specifically aligned on a subscriber station UE. The general signalling channel BCH is transmitted omnidirectionally and the first accesses from the subscriber stations UE in a random access channel RACH are likewise received omnidirectionally. The base station NB transmits and receives in selected directions in all other cases. This applies even to the transmissions following the successful first access in the RACH and the acknowledgement channel FACH.

The example in FIG 1 shows a subscriber station UE located in the radio cell Z of a base station NB. The subscriber station UE has established a communication connection to the base station NB. A signal transmission of a selected service is taking place in both the uplink and the downlink direction over this connection. The

communication connection is separated from communication connections established in parallel in the radio cell Z by one or more spreading codes allocated to the subscriber station UE, in such a way that in each case the subscriber station UE uses all spreading codes currently allocated in the radio cell Z for receiving the signals of its own communication connection in accordance with the known joint detection method.

The frame structure for radio transmission in the TD-SCDMA mobile radio system is shown in FIG 2. The radio interface is embodied as a broadband radio interface having a frequency band B = 1.6 MHz (that is, three frequency bands per 5 MHz), with a time frame length of 5 ms (that is, two time frames fr per UTRA time frame), with 7 time slots ts of 675 µs each for traffic channels, and having CDMA subscriber separation using 16 different spreading codes c0 to c15 (see FIG 3).

In the TDD transmission method shown, the frequency band B for the uplink UL corresponds to the frequency band B for the downlink DL. The same structure is repeated for further carrier frequencies. Variable assignment of the time slots ts for the uplink or downlink UL, DL enables asymmetrical resource allocations to be carried out in a plurality of ways. Some of the time slots td0 to tdn are used as appropriate in transmitting the signal for the downlink DL and the remaining time slots tu0 to tum are used in transmitting the signal for the uplink UL. The parameters n, m and therefore the switching point SP can be individually adapted to a current requirement, where the relationship n+m+2=7 applies. The first time slot td0 for the downlink DL is followed by a guard period for separating the transmission directions DL and UL, represented by the switching point SP.

The guard period consists of a downlink pilot time slot DPTS having a length of 75 µs for transmitting synchronisation sequences differentiated by a set of codes known as gold codes, and of a guard

period GP having a length of 75 µs for the procedure for switching between sending and receiving in the base station NB, and of an uplink pilot time slot UPTS having a length of 125 µs for transmitting a synchronisation sequence in the case of a call attempt by a subscriber station UE followed by signalling on the random access channel RACH. A set of gold codes is also used to differentiate between a plurality of subscriber stations UE during this access procedure.

Information from a plurality of connections is transmitted in radio blocks within the time slots ts. The data d are spread for each individual connection with the aid of a fine structure, a spreading code c, so that for example n connections can be separated reception side by this CDMA component. The effect of spreading individual symbols from the data d is that Q chips with the duration Tc are transmitted within the symbol period Tsym. The Q chips then form the spreading code c for each individual connection. A channel test sequence tseq for reception side channel evaluation is also embedded in the radio blocks. A radio block ends with a guard period gp in each case.

Advantageously the parameters used on the radio interface for the TD-SCDMA system described are:

Chip rate:	1.28 Mchip/s
Frame duration:	5 ms
Number of time slots:	7 (traffic channels)
Time slot duration:	675 µs
Spread factor:	1 to 16
Bandwidth:	1.6 MHz

These parameters enable the best possible harmonisation with the UTRA TDD and FDD modes (FDD stands for frequency division duplex) as well as with the known GSM mobile radio system.
FIG 3 shows a flow diagram of the signalling between a base station NB and a subscriber station UE.

Over the general signalling channel BCH the base station NB periodically transmits information about the organisation of the mobile radio system in the radio coverage area of the base station NB (step 1). When the subscriber station UE is switched on, it first determines a suitable frequency band and then uses the strongest synchronisation sequence sent in the downlink pilot time slot DPTS to select a suitable neighbouring base station NB. After evaluating the organisational information in the BCH of the selected base station NB, the subscriber station UE uses the reception strength of the BCH to determine a corresponding transmission power, and also uses the synchronisation sequence to determine a reception time (step 2) in which subsequently to transmit a synchronisation sequence in the uplink pilot time slot UPTS (step 3), for which purpose it selects a gold code that is suitable for the synchronisation sequence. This procedure is known as downlink synchronisation.

Even though the base station NB receives the synchronisation sequence for downlink synchronisation, the distance of the subscriber station UE from the base station NB is still unknown, which has the disadvantage of leading to unsynchronised uplink signal transmission. When the base station NB receives the synchronisation sequence sent by the subscriber station UE in the uplink pilot time slot UPTS in a specific receive window, it determines the reception strength and the timing advance. Having determined these parameters, the base station NB uses them to determine the content of the synchronisation shift information SS (step 4), which it then transmits to the subscriber station UE in an acknowledgement channel FACH (step 5). After receiving the synchronisation shift information SS in the FACH, the subscriber station UE controls the transmission power and the timing advance required for synchronising the uplink signal transmission (step 6). The connection procedure can then be continued or data can be transmitted in an allocated transmission channel (step 7).

Since the training sequences of a plurality of active subscriber stations in the same time slot are only timing advanced versions of a single periodic base code, the base station NB is able to detect the training sequences sequentially. According to a defined tolerance in the subscriber stations for uplink synchronisation purposes, the base station NB can determine periodically, for example on a time frame basis, synchronisation shift information SS for each (step 8) and send this to the subscriber stations UE via the FACH (step 5).

The synchronisation shift information SS may consist for example of layer 1 signalling PC (power control) and TA (timing advance). According to the described prior art, at least one fixed value is assumed for the timing parameter, that is the timing advance is controlled using a fixed increment. Thus for example the timing advance is regulated on a chip basis, that is, with each signalled item of synchronisation shift information SS the time base for the uplink signal transmission is advanced or delayed by one chip or, according to the invention, by one clock rate cycle.

In the case of a CDMA transmission method a structure for the transmission device of the subscriber station is used as shown for instance in FIG 4. A data stream from a message source is to be transmitted on the radio interface. For this purpose source and channel encoding take place, followed by interleaving of the data stream. After conversion of the data stream into radio blocks, modulation by spreading takes place with the aid of an individual spreading code which allows differentiation of the subscriber signals in the signal multiplex on the radio interface. Next the modulated signals are filtered in a chip pulse filter for pulse shaping the transmission blocks. This is followed by digital/analogue conversion and amplification, after which the signal is transmitted via a transmission antenna on the subscriber station.

FIG 5 explains in detail a typical spreading and modulation sequence such as is known from the referenced prior art according to CATT in chapter 4.5.1.2 Spreading and Modulation, p. 17, Figure 4.9, for the physical transmission channels used in the downlink. This sequence can also be used in the subscriber station for the purpose of spreading and modulating the physical transmission channels used in the uplink.

A corresponding pair consisting of two bits undergoes serial/parallel conversion S/P and is mapped onto an I or Q branch respectively. The I and Q branches are then spread by means of a uniform individual spreading code c to the chip rate. In a downstream lowpass filter LP each chip undergoes filtering for pulse shaping. The impulse response h(t) of the pulse shaping filter corresponds for example to a RRC (root-raised cosine), the impulse response h(t) being defined as

$$h(t)=\frac{\sin\pi\frac{t}{Tc}}{\pi\frac{t}{Tc}}\cdot\frac{\cos\alpha\pi\frac{t}{Tc}}{1-4\alpha^2\frac{t^2}{Tc^2}}$$

with a roll-off factor α = 0.22 and a chip duration Tc = 0.78125µs. According to the invention, the desired timing advance for synchronising the uplink signal transmission can be controlled in different ways in the pulse shaping filter. A possible embodiment of the described alternative solutions will be explained by reference to FIG 6 and the table that follow.

The example in FIG 6 is based on the combination of two configurable parameters for generating a defined timing advance during pulse shaping in the pulse shaping filter. The parameters are chosen from a defined set of filter coefficients 0 to 3 during for example oversampling at double the chip rate, as well as during buffering of the impulse response. Each set of coefficients 0 to 3 corresponds to a sampling of the impulse response advanced in each case by 1/8 chip duration from the pulse shaping filter. The combination of the double rate oversampling and the time advanced sets of coefficients

produces a time resolution of 1/8 chip duration. Thus each set of filter coefficients corresponds to sampling a version of the buffered impulse response which has been time advanced by 1/8 chip. The filter coefficient sets 0 to 3 are buffered in a special memory device, for example, and selected according to the desired timing advance TA. A possible alternative is to use a single filter coefficient set which is shifted and adaptively modified by a defined timing advance in each case.

The table below shows the possible ways in which the described parameter pair can be combined and the timing advance TA which can be obtained thereby.

TA in chip	Adds 1/2 chip	Filter coefficient set
0	no	0
1/8	no	1
1/4	no	2
3/8	no	3
1/2	yes	0
5/8	yes	1
. . .	. . .	. . .

The respective sampling points displayed in FIG 6 and identified by the number of the filter coefficient set are referenced to the filter coefficient set 0 without additional buffering or the addition of 1/2 chip (no). FIG 6 makes it clear that due to the relative offset between the sampling points in steps amounting to 1/8 of the chip duration, and the [lacuna], a large control latitude for the timing advance TA, accompanied by a small time variation (1/8 chip duration), and therefore very accurate time control of uplink signal transmission, are made possible.

Claims

1. Method of carrying out an uplink (UL) synchronisation of the signal transmission in a radio communication system, in which the radio communication system supports a CDMA subscriber separation method for the signal transmission on a radio interface between a base station (NB) and at least one subscriber station (UE), and in which in the subscriber station (UE) the signals to be transmitted in the digital baseband are spread over a corresponding transmission block with the aid of an individual spreading code (c) consisting of a number of chips, characterised in that whilst the chips of the transmission block are undergoing pulse shaping a corresponding impulse response is buffered, and in that the buffered impulse response is sampled with the aid of filter coefficient sets (0, 1, 2, 3), such that the filter coefficient sets (0, 1, 2, 3) have a timing advance relative to one another corresponding to a clock rate which is a multiple of the chip rate, and in that a timing advance for the transmission block is controlled by selecting a sampling point and/or a filter coefficient set (0, 1, 2, 3).

2. Method according to Claim 1, in which the clock rate is selected as a whole number multiple of the chip rate, in particular a 2^n-fold multiple where n = 1, 2, . . ., and so on.

3. Method according to Claim 1, in which the filter coefficient sets (0, 1, 2, 3) are adaptively determined and/or buffered.

4. Subscriber station (UE) of a radio communication system, with

- Means for determining a timing advance for transmitting signals on a radio interface to a base station (NB),
- Means for spreading the signals to be transmitted with the aid of a spreading code (c) consisting of a number of chips in a digital baseband,
- Means for storing an impulse response generated when chips are undergoing pulse shaping,
- Means for sampling the stored impulse response with the aid of a plurality of filter coefficient sets (0, 1, 2, 3), such that the filter coefficient sets (0, 1, 2, 3) have a timing advance

relative to one another corresponding to a clock rate which is a multiple of the chip rate, and

- Means for controlling the timing advance for transmitting the signals by selecting a sampling point and/or a filter coefficient set (0, 1, 2, 3).

5. Subscriber station (UE) according to Claim 4, with means for storing and/or adaptively determining the filter coefficient sets (0, 1, 2, 3).